Missouri Department of Natural Resources
Water Protection Program

Total Maximum Daily Loads (TMDLs)

for

Tributary to Big Otter Creek
Henry County, Missouri

Completed: August 29, 2004
Approved: October 21, 2004

Phased Total Maximum Daily Load (TMDL)
Tributary to Big Otter Creek
Pollutant: pH

Name: Tributary to Big Otter Creek

Location: Near Brownington in southern Henry and northern St. Clair Counties, Missouri

Hydrologic Unit Code (HUC): 10290108

Water Body Identifications (WBID):
1225 Tributary to Big Otter Creek


State map showing location of watershed

Missouri Stream Classifications: Tributary to Big Otter Creek is classified in the Missouri Water Quality Standards as a C[1] stream.

Beneficial Uses for the Tributary to Big Otter Creek[2]:
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life and Human Health [associated with] Fish Consumption

Pollutant: Acidity (low pH)

Size of Impaired Segment: Tributary to Big Otter Creek - 1 mile

Location of Impaired Segment: From Sec 31, T40N, R25W to Sec 5, T39N, R 25W

Pollutant Source: Otter Creek Coal Area

TMDL Priority Ranking: Medium

NOTE: Big Otter Creek (WB 1224, 1 mile) was also listed on the 1998 303(d) Impaired Waters list for low pH, however, existing data indicate pH in the stream does not fall below the minimum Water Quality Standard of 6.5 SU. Big Otter Creek will be proposed for delisting in the next listing cycle.

1.0 Background and Water Quality Problems

Tributary to Big Otter Creek is ultimately a tributary of the South Grand River and is located in northern St. Clair County and southern Henry County. Its drainage area includes 75 acres of acidic coal wastes from the

[1] Class C streams may cease to flow in dry periods but maintain permanent pools that support aquatic life. See 10 CSR 20-7.031(1)(F)
[2] For Beneficial uses see 10 CSR 20-7.031()(C) and Table (H)

Otter Creek Abandoned Mine Land. Acid mine drainage was believed to affect all of Big Otter Creek between this coal waste area and Truman Reservoir. This resulted in numerous fish kills in the stream. The last mine-related fish kill in Big Otter Creek occurred in 1987. Landowners along the creek asserted that the poor water quality was affecting their livestock.[3] The Department of Natural Resources reclaimed this area in 1998 at a cost of $955,964. A 25 acre lake provides water to dilute the acid mine drainage, and a small dilution pond was constructed to collect the numerous acid seeps. The area was revegetated with native warm and cool season grasses.

Sulfide minerals, commonly found in coal and the surrounding rock, oxidize when exposed to the air and are subsequently dissolved by surface flows and groundwater. This weathering process results in sulfuric acid forming and then showing up in the surface runoff and shallow groundwaters that feed the creeks. Freshwater aquatic life cannot tolerate acidic (low pH) water. Water quality sampling in 1999 showed the Tributary to Big Otter contained water too acidic to meet state water quality standards. However, data obtained to date does not show an impact on Big Otter Creek downstream of the acidic tributary. It was thought that during portions of the year, Big Otter Creek would also be impaired, so it was added to the 1998 impaired waters list. As noted above, Big Otter Creek will be proposed for delisting from Missouri's Impaired Waters List at the next listing cycle. Water quality monitoring of both Big Otter Creek and this tributary continues.

1.1 Geophysical and Hydrologic Characteristics of Basin

Henry County and St. Clair County are located in west central Missouri. The location is an upland prairie area with gently sloping to steep topography. The strip mined area is designated in the St. Clair County Soil Survey as Kanima shaly silty clay with 10 to 50 percent slopes. This very steep, well-drained soil is found in spoil banks in upland areas and range from 10 to 200 acres in size. Permeability is moderate and surface runoff is rapid. Organic matter content and fertility is low. This soil can be suitable for pasture if the area is shaped to conform to surrounding topography and if less acid soil is added to allow growth of vegetation. Most areas, however, are better suited for wildlife habitat or recreational use. The soil survey suggests planting warm season grasses or legumes to control erosion on this soil. Suggested natural vegetation for typical southern Henry County/northern St. Clair soils include native grasses like big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparius*), Indian grass (*Sorghastrum nutans*) and switchgrass (*Panicum virgatum*).

This part of Henry/St. Clair Counties is in the Osage Plains natural division. Historically, this area was unaffected by glaciers and is characterized by gently rolling hills and plains.

Soils are derived from underlying bedrock rather than from deposition by glaciers or by wind-blown soil. The Osage Plains are typically less rugged and lower in elevation than the Ozarks Division and has few caves, springs or sinkholes.

Precipitation averaged 39.99 inches for the Henry/St. Clair County area for the 1999-2002 time period. The Otter Creek sub-basin flows northeast and drains into the South Grand River system. The South Grand River then flows into the Osage River, which is now impounded by Truman Dam in neighboring Benton County.

[3] Land Reclamation Program Biennial Report, 1997-1998, Missouri Department of Natural Resources, www.dnr.mo.gov/

1.2 Point Sources Located in the Basin

There are no point source discharges that would affect acidity in the Tributary to Big Otter Creek basin.

2.0 Description of the Applicable Water Quality Standards and Numeric Water Quality Targets

Beneficial Uses

The beneficial uses for Tributary to Big Otter Creek are:

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life and Human Health associated with Fish Consumption.

Use that is impaired

- Protection of Warm Water Aquatic Life and Human Health associated with Fish Consumption

Anti-degradation Policy

Missouri's Water Quality Standards include the Environmental Protection Agency (EPA) "three-tiered" approach to anti-degradation, and may be found at 10 CSR 20-7.031(2).

Tier I defines baseline conditions for all waters and it requires that existing beneficial uses be protected. TMDLs would normally be based on this tier when waters are impacted by pollutants originating before the enactment of the Clean Water Law, assuring that numeric criteria (such as dissolved oxygen and ammonia) are met to protect uses.

Tier II requires that no degradation of high-quality waters occur unless limited lowering of quality is shown to be necessary for "economic and social development." In absence of socioeconomic justification for lowered water quality, TMDLs must be based on maintaining existing water quality.

Tier III (the most stringent tier) applies to waters designated in the water quality standards as outstanding state and national resource waters; Tier III requires that no degradation under any conditions occurs. Management may prohibit discharge or certain polluting activities. TMDLs must assure no measurable increase in pollutant loading.

These TMDLs will result in the protection of existing beneficial uses, which conforms to Missouri's Tier I anti-degradation policy.

Specific Criteria

pH Standards

Missouri's Water Quality Standards (WQS), 10 CSR20-7.031 Section (4)(E), states that water contaminants shall not cause pH to be outside of the range of 6.5-9.0 SU.

Numeric Water Quality Targets

Numeric Water Quality Target for pH: pH is the expression of hydrogen ion activity in water and is highly dependent on chemical reactions that consume or produce hydrogen ions. In natural waters these chemical reactions determine the assimilative "buffering" capacity of the solution to neutralize additional acidity or alkalinity. Therefore, for TMDL loading purposes, an alkalinity target is also being required to ensure the pH will not be below 6.5 SU in Tributary to Big Otter Creek.

As discussed in the Margin of Safety (Section 4.0), the pH criterion alone may not provide sufficient assurance that the proper pH range will be maintained in Tributary to Big Otter Creek. This is due to possible latent acidity. Net alkalinity is the preferred secondary water quality target because it may be treated as a conservative constituent. However, the lack of acidity data for the site makes a statistical analysis of net alkalinity difficult. Review of data from these sites suggests that total acidity will not be significant at higher total alkalinity values. Thus, total alkalinity is a good approximation of net alkalinity at Tributary to Big Otter Creek. For this reason, total alkalinity will be used as the secondary numeric water quality target. To assure that the pH water quality standard is met and maintained in Tributary to Big Otter Creek, a total alkalinity concentration of at least 45.0 mg/L should be maintained.

3.0 Loading Capacity – Linking Water Quality and Pollutant Sources

The Loading Capacity (LC) is the greatest amount of pollutant loading that a stream can assimilate without becoming impaired. It is equal to the sum of the Load Allocation (LA), the Wasteload Allocation (WLA) and the Margin of Safety (MOS).

(LC = LA + WLA + MOS)

Since this is a nonpoint pollutant source, however, no single design flow can be used and thus the TMDL target cannot be mass-based.

Dry weather design flow from the Otter Creek AML can not be accurately determined because surface flow and seepage rates from this area are variable. Tributary to Big Otter Creek, a Class C stream, ceases to flow in dry periods but maintains permanent pools that support aquatic life. Dry weather design flow is therefore 0.1 cfs or less. Since there can be minimal upstream dilution during dry weather conditions, the flow of water coming from the Otter Creek AML areas will have to meet in-stream water quality standards for pH (6.5-9.0 SU) and an alkalinity concentration of at least 45.0 mg/L. The pH and alkalinity concentrations used as the TMDL endpoints can not be expressed as Load Allocations (LAs) + Wasteload Allocations (WLAs) + Margin of Safety (MOS). The standard Load Capacity equation shown above is not applicable when calculating pH and concentration-based endpoints.

For pH as expressed as the concentration in the abandoned mine drainage, the concentration-equivalent load capacity is a pH of 6.5-9.0 SU (the state water quality standard) and a total alkalinity concentration of at least 45.0 mg/L. To ensure that the pH water quality standard is met and maintained in Tributary to Big Otter Creek, the alkalinity target is set at 45.0 mg/L or greater year round.

Load Allocations (Nonpoint Source Load)

Load Allocation is the maximum allowable amount of pollutant loading that can be assigned to nonpoint sources.

pH

Tributary to Big Otter Creek—Since the load capacity for Tributary to Big Otter Creek is concentration based, discharges to the stream will be required to meet the 45.0 mg/L alkalinity target. This target will allow the standard of 6.5 to 9.0 SU be met.

Wasteload Allocation (Point Source Load)

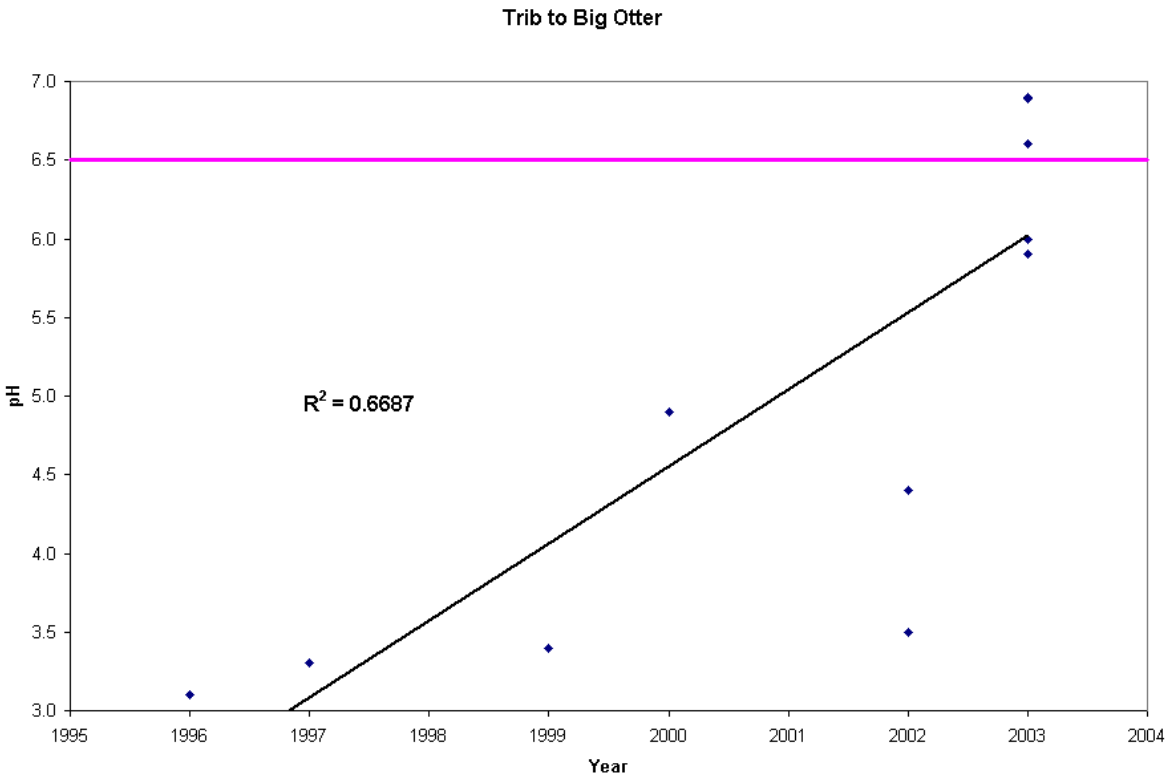
The Wasteload Allocation is the maximum allowable amount of the pollutant that can be assigned to point sources. In this phase of the TMDL the WLA equals zero because there are presently no point sources discharging to the affected segment of Tributary to Big Otter Creek. Any future discharges would be required by Missouri State Operating Permit (per the EPA NPDES permit) to maintain a pH in the range of 6.5 – 9.0 SU and a secondary requirement for a total alkalinity of 45.0 mg/L.

4.0 Margin of Safety

The pH criterion alone may not provide sufficient assurance that the proper pH range will be maintained in Tributary to Big Otter Creek due to possible latent acidity. Net alkalinity would be the preferred secondary water quality target, but the lack of sufficient acidity data make this analysis difficult. As a result, in-stream alkalinity will be used as the secondary water quality target. Alkalinity is a measurable characteristic in Tributary to Big Otter Creek and can be linked to the pH water quality criterion. Alkalinity has units of mg/L as $CaCO_3$ (calcium carbonate) as discussed in Standard Methods for the Examination of Water and Wastewater.

There is an increasing trend in pH values in the Tributary to Big Otter Creek (Fig.: 1 below). The data suggest that the land reclamation work performed at the site is achieving positive results as mine seepage is contained and vegetation is established. If the coal mined land remains undisturbed, Tributary to Big Otter Creek will soon achieve water quality standards.

Fig.: 1: pH data in the Trib to Big Otter Creek



An Ordinary Least Squares (OLS) approach was used to calculate a regression line and associated statistics for pH and alkalinity data collected in the Big Otter Creek watershed (Appendix C). Alkalinity standard residuals were computed, plotted and examined for outliers. Any data with standard residual values greater than ± 3.0 were considered outliers and not included in the analysis. Residuals were also tested for normality and found to adhere to a normal distribution. The predicted alkalinity associated with a pH of 6.5 is 45 mg/L [(6.5-5.88)/0.015=41.33, rounded up to 45]. An in-stream alkalinity concentration of 45.0 mg/L alkalinity should ensure adequate buffering to prevent in-stream pH values from dropping below 6.5. Because conservative assumptions were used, the margin of safety is implicit.

5.0 Seasonal Variation
The water quality data collected to this point represents all seasons. The primary processes involved in the formation of acid water and the oxidation of sulfide are not significantly affected by differences in air and water temperatures associated with seasonal change. Missouri standards do not distinguish between summer and winter for pH.

6.0 Reasonable Assurance
The department's Water Protection Program will continue low-flow water chemical monitoring of the impaired segments of the Big Otter Creek system. Periodic review of the department's Water Quality Management Plans and monitoring data should provide reasonable assurance that Tributary to Big Otter Creek will meet water quality standards.

7.0 Implementation Plans
Prior reclamation projects in Big Otter Creek watershed have cost $955,964. It is possible that more wetland cells could be constructed to treat underground water seeps, as has been done in the Big Otter Creek area and other abandoned mine land sites around the state. These projects are very expensive, however, and wetland cells would have to be constructed in many locations to handle acidic underground flows. Monitoring will continue to determine how successful the reclamation work has been up to this point. Implementation of any further reclamation work will be addressed as future technological advances are made and program funding allows.

The alkalinity vs. pH regression model will be rerun in 2006 with the new data collected in 2004 and 2005 to determine whether the trend is toward meeting water quality goals. This TMDL will be incorporated into Missouri's Water Quality Management Plan.

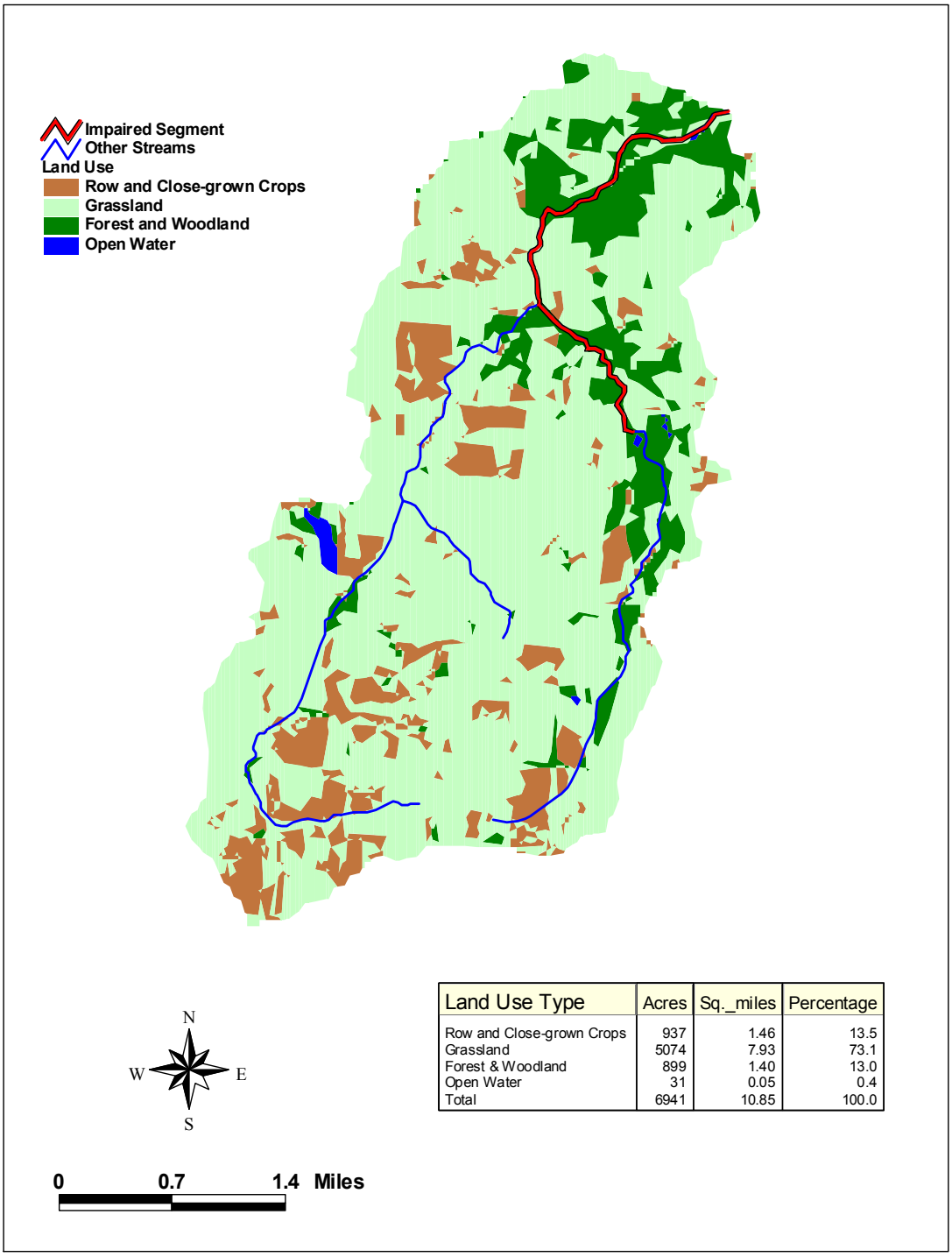
8.0 Monitoring Plan
Monitoring on Big Otter Creek and Tributary to Big Otter Creek will be done annually. Ambient and low flow monitoring for chloride, sulfate, alkalinity, pH and acidity will be done four times a year.

9.0 Public Participation
The water quality limited segments of Tributary to Big Otter Creek are included on the approved 1998 303(d) list for Missouri. The Missouri Department of Natural Resources, Division of Environmental Quality, Water Pollution Control Program developed these TMDLs. Six public meetings to allow input from the public on impaired waters were held between August 18 and September 22, 1999. No comments pertaining to Tributary to Big Otter Creek were received during the public meetings. Department staff spoke to the Henry County Conservation District Board regarding upcoming TMDLs in their county, including the Tributary to Big Otter Creek on April 4, 2002. In this presentation staff explained what TMDLs are and what to expect when a TMDL is written on an impaired waterbody. Tributary to Big Otter Creek TMDL was placed on public notice from July 30, 2004 to August 29, 2004. One comment letter was received during the comment period. A slight language modification was made in the document prior to submission to EPA.

10.0 Administrative Record and Supporting Documentation:
Appendix A - Land Use
Appendix B - Location Map
Appendix C - Statistical Analysis
Appendix D - Data

Documents on file with the Department:
Public notice announcement
Public comments
MDNR's response to public comments

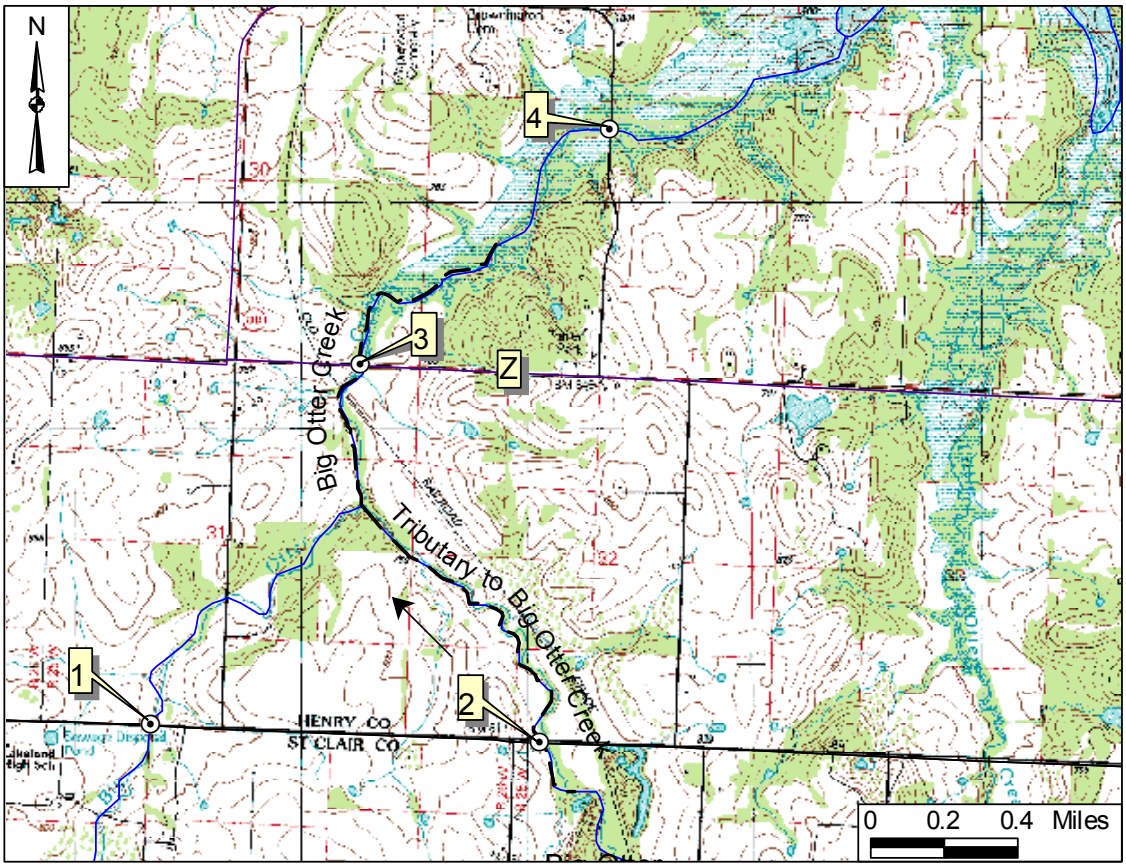
Appendix A
Land Use Map of Big Otter Creek Area



Land Use Type	Acres	Sq._miles	Percentage
Row and Close-grown Crops	937	1.46	13.5
Grassland	5074	7.93	73.1
Forest & Woodland	899	1.40	13.0
Open Water	31	0.05	0.4
Total	6941	10.85	100.0

Appendix B

Map of Big Otter Creek and Tributary to Big Otter Creek Showing Sampling Locations



Sampling Sites

Site #1 Big Otter Creek
Site #2 Trib. Big Otter Cr. 0.5mi.bl. AML
Site #3 Big Otter Cr. at Hwy Z
Site #4 Big Otter Cr. near mouth

Appendix C
Statistical Analysis

Regression Statistics	
Multiple R	0.62504
R Square	0.39067
Adjusted R Square	0.36165
Standard Error	0.90985
Observations	23

Ordinary Least Squares (OLS) Analysis
Tributary to Big Otter Creek,
Henry County, Missouri

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	11.14604	11.14604	13.46408	0.00143
Residual	21	17.38455	0.82784		
Total	22	28.53059			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	5.88577	0.30077	19.56872	0.00000	5.26028	6.51127
X Variable 1	0.01511	0.00412	3.66934	0.00143	0.00655	0.02368

Appendix D
DATA

Site	Site Name	Year	Month	Day	Time	Flow	Temp °C	DO	pH	SC	Alk	Acid	SO4	Cl
Site #1	Big Otter Cr.	1996	2				11		8.1	730				
Site #1	Big Otter Cr.	1997	10			0	11		7	310				
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	1996	2			0.1	10		**3.1**	1370				
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	1997	10			0	11		**3.3**	1150				
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	2000	8	4	1200	0			**4.9**	290	0	4	125	6
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	2002	7	5		0.01	26		**3.5**	580	2.5	118	361	5.9
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	2002	8	28	1115	0	22		**4.4**	412	2.5	136	169	8
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	2003	5	14	1120		17	7.6	6.6	420	11	32	140	15
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	2003	5	29	1120		18	6.9	6.9	505	2.5	74	198	14
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	2003	6	10	900		18	7.1	6.6	622	10	42	126	14
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	2003	7	29	1010	0	23		**6**	510	2.5	12	196	13
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	2003	12	3	1225	1	3	12	6.9	582	2.5	33	143	12
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	2003	12	30	1120	1	4.5		**5.9**	295	5	50	100	11
Site #2	Trib. Big Otter Cr. 0.5mi.bl. AML	2004	2	25	1310		4	11	7	520	6	16	133	16
Site #3	Big Otter Cr. at Hwy Z	1997	10			0	14		7.3	536				
Site #3	Big Otter Cr. at Hwy Z	2002	7	5		0.3	27		7.2	693	156	2.5	96	50
Site #3	Big Otter Cr. at Hwy Z	2002	8	28	1100	0								
Site #3	Big Otter Cr. at Hwy Z	2003	5	14	1040		16	8.6	7.2	377	86	2.5	75	16
Site #3	Big Otter Cr. at Hwy Z	2003	5	29	1050		17	7.4	7	460	101	2.5	78	17
Site #3	Big Otter Cr. at Hwy Z	2003	6	10	830		18	7.3	7.3	790	95	2.5	66	17
Site #3	Big Otter Cr. at Hwy Z	2003	12	3	1210		4	11	7.1	466	124	2.5	98	40
Site #3	Big Otter Cr. at Hwy Z	2003	12	30	1110	1.5	4		7.3	323	56	2.5	69	14
Site #3	Big Otter Cr. at Hwy Z	2004	2	25	1230		5	10	7.5	460	66	2.5	81	19
Site #4	Big Otter Cr. near mouth	2003	5	14	1210		17	8	7.2	520	85	2.5	95	19
Site #4	Big Otter Cr. near mouth	2003	5	29	1200		18	7.4	7.4	563	90	2.5	74	19
Site #4	Big Otter Cr. near mouth	2003	6	10	940		19	7.9	7.4	497	88	2.5	65	18
Site #4	Big Otter Cr. near mouth	2003	12	3	1245		4	11	7.5	489	90	2.5	94	27
Site #4	Big Otter Cr. near mouth	2004	2	25	1135		4	9.8	7.6	485	57	2.5	93	19

Bolded numbers indicate values outside Water Quality Standards of 6.5-9.0
Big Otter Creek is site #1 on the topographical map
Tributary Big Otter Creek 0.5 mile below AML is site #2 on the topo map
Big Otter Creek at highway Z site is site #3 on the topo map
Big Otter Creek near mouth site is site #4 on the topo map